# GUIDE FOR SOLID INK STICK FEED

**[0001]** The present invention relates generally to ink printers, the ink used in such ink printers, and the apparatus and method for feeding the ink into the printer.

## BACKGROUND AND SUMMARY

**[0002]** Solid ink or phase change ink printers conventionally receive ink in a solid form, either as pellets or as ink sticks. A feed mechanism delivers the solid ink to a heater assembly, where the ink is melted into a liquid state for jetting onto a receiving medium.

**[0003]** The printer may receive the solid ink as pellets or as ink sticks in a feed chute. With solid ink sticks, the solid ink sticks are either gravity fed or spring loaded through the feed chute toward a heater plate. The heater plate melts the solid ink into its liquid form. In a printer that receives solid ink sticks, the sticks are gravity fed or spring loaded along a feed channel and pressed against a heater plate to melt the solid ink into its liquid form. United States Patent No. 5,734,402 for a Solid Ink Feed System, issued March 31, 1998 to Rousseau et al.; and United States Patent No. 5,861,903 for an Ink Feed System, issued January 19, 1999 to Crawford et al. describe exemplary systems for delivering solid ink sticks into a phase change ink printer. United States Patent Application Publication No. 20030202077, published October 30, 2003 by Brent R. Jones and Frederick T. Mattern, and entitled "Guide for Solid Ink Stick Feed" describes another ink delivery system and the contents thereof are hereby incorporated by reference.

**[0004]** In accordance with an aspect of the present invention, a feed system for a phase change ink printer includes a longitudinal feed channel for guiding solid

ink sticks along a path form an insertion point to a melt plate. The surfaces of the feed channel that come into contact with the ink stick are formed of, or coated with, a non-marking material. The non-marking material is a material having a very low surface energy, to which the ink material does not adhere or build up, and/or that readily sheds any ink material that should adhere. Exemplary non-marking materials include tetrafluoroethylene (TFE) fluorocarbon polymers or fluorinated ethylene-propylene (FEP) resins. In a particular embodiment, the surfaces of the feed channel are covered with a film tape of polyetrafluoroethylene (PTFE) or similar material.

**[0005]** Further in accordance with aspects of the present invention, a method of forming a solid ink feed system having a longitudinal feed channel includes applying a non-marking coating to a surface of the solid ink feed system against which an ink stick forms a load bearing contact as the ink stick traverses the solid ink feed system. In a particular embodiment, applying the tape comprises applying a tape of extruded polyetrafluoroethylene film. Also in a particular embodiment, the solid ink feed system includes a feed channel guide rail adapted so that when an ink stick is inserted into the feed channel, a portion of the ink stick forms a load-bearing contact with the feed channel guide rail, and applying the tape comprises applying the tape to the feed channel guide rail.

## THE DRAWINGS

**[0006]** Figure 1 is a perspective view of a phase change printer with the printer top cover closed.

**[0007]** Figure 2 is an enlarged partial top perspective view of the phase change printer with the ink access cover open, showing a solid ink stick in position to be loaded into a feed channel.

**[0008]** Figure 3 is a side sectional view of a feed channel of a solid ink feed system taken along line 3 – 3 of Figure 2.

[0009] Figure 4 is a simplified cross-sectional view of a feed channel taken along line 4 – 4 of Figure 3.

[0010] Figure 5 is a perspective view of one embodiment of a solid ink stick for use in the feed channel of Figure 4.

[0011] Figure 6 is an end elevational view of the ink stick of Figure 5.

[0012] Figure 7 is a simplified cross-sectional view of an alternate feed channel and ink stick.

[0013] Figure 8 is a simplified cross-sectional view of yet another alternate feed channel and ink stick.

[0014] Figure 9 is a perspective view of another embodiment of a phase change printer with the printer ink access cover open.

[0015] Figure 10 is a side sectional view of one embodiment of a feed channel of a solid ink feed system, taken along line 10 – 10 of Figure 9.

[0016] Figure 11 is a sectional view of the ink stick feed system, taken along line 11 – 11 of Figure 9.

[0017] Figure 12 is a perspective view of an embodiment of a solid ink stick suitable for use in the ink stick feed system of Figures 10 and 11.

[0018] Figure 13 is a simplified cross-sectional view of a feed channel taken along line 13 – 13 of Figure 10.

[0019] Figure 14 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

[0020] Figure 15 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

[0021] Figure 16 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

**[0022]** Figure 17 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

**[0023]** Figure 18 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

**[0024]** Figure 19 is an end elevational view of the solid ink stick shown in Figure 18.

**[0025]** Figure 20 is a perspective view of yet another embodiment of a solid ink stick.

**[0026]** Figure 21 is a perspective view of yet another embodiment of a solid ink stick.

**[0027]** Figure 22 is a simplified cross-sectional view of another embodiment of a feed channel, with another embodiment of a solid ink stick.

**[0028]** Figure 23 is a simplified cross-sectional view of yet another embodiment of a feed channel.

## DETAILED DESCRIPTION

**[0029]** Figure 1 shows a solid ink, or phase change, ink printer 10 that includes an outer housing having a top surface 12 and side surfaces 14. A user interface display, such as a front panel display screen 16, displays information concerning the status of the printer, and user instructions. Buttons 18 or other control elements for controlling operation of the printer are adjacent the user interface window, or may be at other locations on the printer. An ink jet printing mechanism (not shown) is contained inside the housing. Such a printing mechanism is described in United States Patent No. 5,805,191, entitled Surface Application System, to Jones et al, and United States Patent No. 5,455,604, entitled Ink Jet Printer Architecture and Method, to Adams et al. An ink feed system delivers ink to the printing mechanism. The ink

feed system is contained under the top surface of the printer housing. The top surface of the housing includes a hinged ink access cover 20 that opens as shown in Figure 2, to provide the user access to the ink feed system.

**[0030]** In the particular printer shown, the ink access cover 20 is attached to an ink load linkage element 22 so that when the printer ink access cover 20 is raised, the ink load linkage 22 slides and pivots to an ink load position. The interaction of the ink access cover and the ink load linkage element is described in United States Patent No. 5,861,903 for an Ink Feed System, issued January 19, 1999 to Crawford et al., though with some differences noted below. As seen in Figure 2, opening the ink access cover reveals a key plate 26 having keyed openings 24A-D. Each keyed opening 24A, 24B, 24C, 24D provides access to an insertion end of one of several individual feed channels 28A, 28B, 28C, 28D of the solid ink feed system (see Figures 2 and 3).

**[0031]** Each longitudinal feed channel 28A-D delivers ink sticks 30 of one particular color to a corresponding melt plate 32. Each feed channel has a longitudinal feed direction from the insertion end of the feed channel to the melt end of the feed channel. The melt end of the feed channel is adjacent the melt plate. The melt plate melts the solid ink stick into a liquid form. The melted ink drips through a gap 33 between the melt end of the feed channel and the melt plate, and into a liquid ink reservoir (not shown). The feed channels 28A-D have a longitudinal dimension from the insertion end to the melt end, and a lateral dimension, substantially perpendicular to the longitudinal dimension. Each feed channel in the particular embodiment illustrated includes a push block 34 driven by a driving force or element, such as a constant force spring 36, to push the individual ink sticks along the length of the longitudinal feed channel toward the melt plates 32 that are at the melt end of each feed channel. The tension of the constant force spring 36 drives the push block toward the melt end of the feed channel. As described in United States Patent No. 5,861,903, the ink load linkage 22 is coupled to a yoke 38, which is

attached to the constant force spring 36 mounted in the push block 34. The attachment to the ink load linkage 22 pulls the push block 34 toward the insertion end of the feed channel when the ink access cover is raised to reveal the key plate 26.

**[0032]** A color printer typically uses four colors of ink (yellow, cyan, magenta, and black). Ink sticks 30 of each color are delivered through a corresponding individual one of the feed channels 28A-D. The operator of the printer exercises cares to avoid inserting ink sticks of one color into a feed channel for a different color. Ink sticks may be so saturated with color dye that it may be difficult for a printer user to tell by color alone which color is which. Cyan, magenta, and black ink sticks in particular can be difficult to distinguish visually based on color appearance. The key plate 26 has keyed openings 24A, 24B, 24C, 24D to aid the printer user in ensuring that only ink sticks of the proper color are inserted into each feed channel. Each keyed opening 24A, 24B, 24C, 24D of the key plate has a unique shape. The ink sticks 30 of the color for that feed channel have a shape corresponding to the shape of the keyed opening. The keyed openings and corresponding ink stick shapes exclude from each ink feed channel ink sticks of all colors except the ink sticks of the proper color for that feed channel.

**[0033]** Referring next to Figure 4, the feed channel 28 is defined by lateral side walls 42, 44 that are substantially vertical, and a bottom 46. The transverse dimension is between the lateral side walls 42, 44. A longitudinal feed channel guide rail 40 is included in a lower portion of the feed channel, preferably near the bottom of the feed channel. This feed channel guide rail 40 is substantially centered in the lateral dimension in the feed channel, as shown in Figure 4, so that it is aligned with the central longitudinal axis of the feed channel. The guide rail 40 is designed to receive the bottom surface of an ink stick. The exemplary feed channel guide rail illustrated is approximately the shape of an inverted "V" with a truncated peak, so that the width of the feed channel guide rail 40 at its peak is substantially less than the width of the feed channel between the side walls 42, 44.

**[0034]** All or portions of the surface of the feed channel guide rail is formed of material to which the material forming the ink sticks does not adhere, accumulate, or build up, or that readily sheds the ink stick material. In this document, such material is referred to as "non-marking" material. This surface material has a low surface energy.

**[0035]** The ink stick material does not accumulate on the non-marking material even at the relatively elevated temperatures that sometimes exist in the interior of the printer housing. Such elevated temperatures may arise due to heat that radiates from the heater plates used to melt the ink sticks at the end of each ink stick feed channel. At the elevated temperatures that may exist in the interior of the printer housing, the surface of the ink sticks may soften slightly and become "tacky." Even in such condition, the ink stick material does not accumulate on the non-marking material. The non-marking material surface is smooth so that it does not abrade the ink sticks.

**[0036]** In particular implementations, a coating 41 of such a non-marking material is applied to at least portion of the surface of the feed channel guide rail 40. This coating is applied to at least those portions of the guide rail that come into contact with the ink stick 30 as the ink stick moves along the length of the feed channel 28, and particularly those surfaces of the guide rail that form load-bearing contact with the ink stick. The coating is formed of a material such as tetrafluoroethylene (TFE) fluorocarbon polymers or fluorinated ethylene-propylene (FEP) resins, such as those marketed by DuPont of Wilmington, Delaware, USA under the name TEFLON®.

**[0037]** In the embodiment shown in Figure 4, the non-marking coating 41 is a film applied over the surface of the feed channel guide rail 40. This film may comprise a film of polyetrafluoroethylene (PTFE). The film may be applied as a tape containing an adhesive backing for attaching the film to the feed channel guide rail. One exemplary PTFE film tape is Silicone-Free PTFE Film Tape 5498, available from

3M of St. Paul, Minnesota, USA. This film tape is an extruded polyetrafluoroethylene (PTFE) film backing with a silicone-free rubber adhesive. The film tape has a total thickness of approximately 4.1 mil (0.10 mm), of which thickness approximately half is the adhesive. The film tape provides a smooth surface that does not abrade the ink stick as the ink stick traverses the feed channel on the feed channel guide rail. The adhesive backing of the tape is compressible so that the smooth surface tape is slightly deformable. The smooth surface of the film tape is more deformable than is the material of the ink sticks. Thus, if an ink stick is forced against the tape surface, the tape yields sufficiently that the ink stick does not become wedged in place.

**[0038]** An exemplary solid ink stick 30 for use in the feed channel with the feed channel guide rail is illustrated in Figures 5 and 6. The ink stick is formed of an ink stick body having a bottom, represented by a general bottom surface 52, a top, represented by a general top surface 54, and at least two lateral extremities or sides, represented by general side surfaces 56. The ink stick is illustrated without the key shapes on the lateral sides that correspond to the key plate openings 24A-D through the key plate 26, to simplify the illustration. The surfaces of the ink stick body need not be flat, nor need they be parallel or perpendicular to one another. However, these descriptions will aid the reader in visualizing, even though the surfaces may have three dimensional topography, or be angled with respect to one another. The bottom of the ink stick body is a bottom surface having lateral edges 58 at which the bottom surface 52 intersects the lateral side surfaces 56. The ink stick body may be formed in a substantially rectangular block in which the lateral side surfaces 56 are substantially parallel one another. Such a rectangular block form of the ink stick body also includes two end surfaces 60 that are substantially parallel to one another, and are substantially perpendicular to the side surfaces 56. Nevertheless, other shapes of the side and end surfaces are also possible, including curved surfaces. As noted above, the side surfaces 56 may also be shaped with the key shapes to match the keyed openings 24 through the key plate 26. The lateral side surfaces can also be segmented or stepped, so that one portion of the ink stick body is narrower than

another. The ink stick body may be formed by pour molding, compression molding, or other formation techniques.

**[0039]** The ink stick body has a lateral center of gravity 63 between the lateral side surfaces 56 of the ink stick body, and a vertical center of gravity 64 between the top and bottom surfaces 52, 54. If the ink stick body has a substantially uniform weight density, the lateral center of gravity 63 is approximately midway between the lateral side surfaces 56 of the ink stick body. The lateral center of gravity 63 is identified in the ink stick body without the key shape elements that may be formed in the lateral side surfaces of the ink stick body.

**[0040]** Guide means including a longitudinal ink stick guide element 66 is formed in the lower portion of the ink stick body for guiding the ink stick 30 along the feed channel guide rail 40 in the feed channel 28. The longitudinal guide element 66 is formed in the bottom surface 52 of the ink stick body, and extends along the entire length of the body between the end surfaces 60. The longitudinal guide element 66 is substantially aligned with the lateral center of gravity 63 of the ink stick body. In the ink stick embodiment illustrated in Figures 5 and 6, the bottom surface 52 of the ink stick body is formed in the shape of an inverted "V", with the peak approximately vertically aligned with the lateral center of gravity of the body to form the ink stick guide element 66. If the ink stick body has a substantially uniform weight density, the peak of the inverted V forming the guide element is substantially midway between the lateral edges 58 of the bottom surface of the ink stick body. Inherent in many ink stick forming techniques is that the corners and edges may have radii, and not be square. In addition, in certain circumstances, radius edges will be desired.

**[0041]** Referring again to Figure 4, the slope of the "V" shape of the ink stick guide element 66 in the bottom surface of the ink stick body is substantially the same as the slope of the feed channel guide rail 40 in the ink feed channel. This common slope between the guide element surface 66 and the feed channel guide rail 40 allows a portion of the ink stick guide element to contact non-marking coating 41 on

the surface of the feed channel guide rail to allow the feed channel guide rail to guide the ink stick along the feed channel, and help to hold the ink stick upright in the feed channel. The primary load-bearing support contact between the bottom surface of the ink stick body and the longitudinal feed channel is the contact between the central guide element in the bottom surface of the ink stick body and the non-marking coating 41 on the surface of the feed channel guide rail. The lateral side portions of the bottom surface of the ink stick body, adjacent the lateral edges 58 of the bottom surface 52 do not generally contact the bottom 46 of the feed channel 28. Therefore, the non-marking coating 41 need not extend along the bottom 46 of the feed channel, nor along the vertical portions of the feed channel guide rail 40 that do not contact the bottom surface of the ink stick. Furthermore, because the peak of the ink stick guide element 66 does not contact the (horizontal) center portion of the feed channel guide rail, the non-marking coating 41 also need not cover that portion of the feed channel guide rail.

**[0042]** In certain applications, it may be desirable to provide portions of the side walls 42, 44 with the non-marking surface, such as by applying strips of the non-marking coating (not shown) to the upper portions of the side walls where the upper edges of the ink stick might contact the side walls should the ink stick tip to one side as it progresses along the feed channel.

**[0043]** The lateral dimension of the ink stick body between the side surfaces 56 is no wider than the lateral dimension of the ink stick feed channel 28 between the side walls 42, 44. The lateral dimension of the ink stick body between the side surfaces 56 is substantially the same as the lateral dimension of the ink stick feed channel 28 between the side walls 42, 44, or more specifically only fractionally smaller than the lateral dimension of the ink stick feed channel 28 between the side walls 42, 44. For example, the ink stick body may have a longitudinal dimension (not including protruding insertion key or orientation elements) between the end surfaces 60 of between approximately 1.1 and 1.8 inches (28 – 46 mm), such as 1.5 inches

(37 mm). The ink stick body may have a lateral dimension (not including protruding insertion key or orientation elements) between the lateral side surfaces 56 of between approximately 1.0 and 1.3 inches (25 – 33 mm), such as 1.3 inches (33 mm). The ink stick body may have a vertical dimension between the bottom and top surfaces 52, 54 of between approximately 1.0 and 1.5 inches (25 – 38 mm), such as 1.25 inches (32 mm). The lateral dimension of the ink stick feed channel 28 between the side walls 42, 44 may be approximately 0.004 to 0.08 inches (0.1 – 2 mm) wider than the lateral dimension of the ink stick body. Thus, the ink stick body 30 remains substantially upright and balanced with the central longitudinal guide element of the ink stick body resting on the feed channel guide rail of the feed channel. To the extent that the ink stick body tilts to one side or the other, one of the upper lateral edges of the ink stick body formed by the intersection of the lateral side surfaces 56 with the top surface 54 may contact a side wall 42, 44 of the feed channel. Thus, substantially the only contact between the bottom surface of the ink stick body and the feed channel is the contact between the longitudinal guide element 66 formed in the bottom surface of the ink stick body, and the guide rail 40 in the feed channel. Minor contact between an upper portion of the lateral side surface 56 of the ink stick body and the side of the feed channel 42, 44 may also occur.

**[0044]** The ink stick guide element 66 in the bottom surface of the ink stick body and the feed channel guide rail 40 in the feed channel cooperate to maintain the orientation of the ink stick as the ink stick progresses along the length of the feed channel from the insertion end to the melt end. The ink stick guide element 66 and the feed channel guide rail 40 forming the guide means keep the ink stick aligned with the feed channel. The ink stick body does not become skewed with respect to the feed channel. With the ink stick properly aligned with the feed channel, the ink stick meets the melt plate 32 normal to the melt plate surface. Proper alignment between the ink stick and the melt plate enhances even melting of the ink stick. Even melting reduces the formation of unmelted corner slivers at the trailing end of each ink stick. Such unmelted corner slivers may slip through the gap 33 between the melt

plate and the end of the feed channel. Such slivers may interfere with the proper functioning of certain portions of the printer. Guiding the ink stick to maintain its alignment in the feed channel also eliminates jamming due to skewing of the ink stick as it moves along the channel.

**[0045]** Key element shapes in the lateral side surfaces 56 of the ink stick body may tend to affect the orientation of the ink stick body as the ink stick moves along the feed channel. The interaction of the guide element 66 and the guide rail 40 counteracts that tendency, and maintains the correct orientation of the ink stick in the feed channel. The cooperative action of the ink stick guide element 66 and the feed channel guide rail 40 also reduce the "steering" effect the push block 34 acting on the trailing end surface of the ink stick in the feed channel 28. Thus, laterally offset pressure by the push block 34 on the ink stick body is of lesser concern, and maintaining a perfect lateral balance of the force exerted by the push block on the ink stick is less critical than with certain other designs.

**[0046]** As seen in Figures 5 and 6, the inverted "V" shape of the ink stick guide element 66 need not necessarily extend all of the way to the lateral edges 58 of the bottom surface of the ink stick body. The outer lateral portions of the bottom surface may be substantially flat, parallel to the top surface 54 of the ink stick body. Various alternative shapes for the bottom surface of the ink stick body can be implemented.

**[0047]** Two additional exemplary embodiments are shown in Figures 7 and 8. The ink stick body embodiment 230 shown in Figure 7 has a bottom surface 252 with an ink stick guide element 266 formed as a non-inverted, or projecting, "V" shape. The bottom surface of the feed channel 228 has a corresponding shape to form the feed channel guide rail 240. In the illustrated embodiment, the feed channel guide rail 240 is formed as two angled channel segments that extend from the side walls 242, 244 toward the center of the feed channel. The interior (upper) surface of each angled channel segment is coated with a non-marking coating 241. The angle of the feed channel guide rail 240 substantially matches the angle of the guide element

266. The feed channel guide rail 240 does not extend across the entire width of the feed channel, providing an opening 243 in the bottom of the feed channel. The bottom opening 243 allows chips and slivers of ink material that break off from the ink stick to fall away, so that they do not interfere with movement of the ink stick along the feed channel. The non-marking coating 241 covers those surfaces of the channel segments that contact the ink stick as the ink stick travels along the feed channel. The non-marking coating 241 is formed of the same types of materials described above for the non-marking coating 41 in connection with the embodiment of Figure 4. The non-marking coating 241 particularly covers the load-bearing surfaces of the feed channel. However, in certain instances, it may be desirable to apply a non-marking coating to portions of the side walls 244 of the feed channel, if the upper edges of the ink sticks may come into significant contact with the feed channel side walls.

**[0048]** The ink stick 330 shown in Figure 8 includes a guide element 366 formed as a concave shape in the bottom 352 of the ink stick body. The concave ink stick guide element 366 cooperates with the feed channel guide rail 340 in the feed channel 328. The surface of the feed channel guide rail 340 facing the interior of the feed channel is coated with a non-marking coating 341. In the illustrated embodiment, the non-marking coating is shown as covering the entire feed channel guide rail 340. However, the non-marking coating may be omitted from certain portions of the feed channel guide rail 340 that do not contact the bottom surface of the ink stick 330. As illustrated, the non-marking coating 340 does not cover the bottom portions 346 of the feed channel. In addition, the non-marking coating could be omitted from the peak of the feed channel guide rail 340, which, in the illustrated implementation, does not contact the bottom surface of the ink stick. The feed channel guide rail 340 and the ink stick guide element 366 have alignment guides 343, 367 to avoid a tendency of the ink stick to rotate about the feed channel guide rail 340 and tilt in the feed channel. The alignment guides illustrated are a longitudinal ridge 343 along the feed channel guide rail 340, and a corresponding

longitudinal notch 367 along the ink stick guide element 366. The guide element can also be formed of a convex shape in the bottom of the ink stick body. The guide element can also be formed of a convex shape in the bottom of the ink stick body.

**[0049]** In accordance with a method of using the ink stick and ink feed system shown, the printer user provides an ink stick such as the ink stick shown in Figures 4 – 6, or the alternative embodiments shown in Figures 7 – 8. The user opens the ink access cover 20, as seen in Figure 2. The user inserts the ink stick 30 through the keyed opening 24A-D in the key plate 26 and into the corresponding feed channel 28A-D. The user inserts the ink stick so that the ink stick guide element 66 formed in the bottom surface of the ink stick body is aligned with the feed channel guide rail 40 in the feed system. The user places the ink stick body in the insertion end of the feed channel so that the ink stick guide element 66 rests on the coated surface of the feed channel guide rail 40. In this way, substantially the only contact between the bottom surface of the ink stick and the feed system is the contact between the guide element in the ink stick body and the non-marking coating 41 of the feed channel guide rail of the feed channel. This contact forms a load-bearing contact between the feed channel and the ink stick. The user then closes the feed system cover 22 and the printer cover 20. The push block 34 pushes the ink stick along the feed channel 28 toward the melt plate 32, with the ink stick guide element 66 sliding along the coated surface of the feed channel guide rail 40 of the feed channel.

**[0050]** Figures 9 – 11 illustrate another embodiment of a phase change ink jet printer with a different embodiment of a key plate 126. Each keyed opening 124A, 124B, 124C, 124D in the key plate 126 provides access to a corresponding feed channel 128A, 128B, 128C, 128D (see Figures 10 and 11).

**[0051]** An exemplary ink stick for use in the printer of Figures 9 – 11 is shown in perspective in Figure 12. The ink stick 130 illustrated is formed of a three dimensional substantially rectangular body of ink material that has a bottom, represented by a bottom surface 152, a top, represented by a top surface 154, and

sides, represented by two lateral side surfaces 156 and two end surfaces 160. In the particular somewhat cubic shape illustrated, the intersections of the bottom surface 152 and the lateral side surfaces 156 of the ink stick body form lateral edges 158A, 158B of the bottom surface. The side surfaces 156 of the illustrated embodiment are stepped or tapered so that the upper portion of the ink stick body is slightly wider than the lower portion. The side surfaces 156 may also be substantially vertical, so that the upper and lower portions of the ink stick body are of substantially equal dimensions. The ink stick is illustrated without the key shapes on the lateral sides that correspond to the key plate openings 124A-D through the key plate 126, to simplify the illustration. The basic ink stick body, including keying features, has a longitudinal dimension between the end surfaces 160 of approximately 0.8 - 2.0 inches (20 – 51 mm), such as 1.2 inch (30 mm). The ink stick body has a lateral dimension between the lateral extremities of between approximately 1.0 and 2.0 inches (25 – 51 mm), such as 1.5 inch (38 mm). The ink stick body has a vertical dimension between the top and bottom surfaces of between approximately 0.8 and 1.6 inches (20 – 41 mm), such as 1.3 inches (34 mm). The lateral dimension of the ink stick feed channel is approximately 0.004 to 0.2 inches (0.1 – 5.0 mm) wider than the lateral dimension of the ink stick body.

**[0052]** The ink stick has a lateral center of gravity 163 between the two lateral sides 156 of the ink stick body. In the particular embodiment illustrated, the weight distribution of the ink stick body is substantially uniform (not including protruding key elements), and the ink stick body is substantially symmetrical about its lateral center (not including protruding key elements), so that the lateral center of gravity 163 is approximately at the midpoint between the lateral sides 156 of the ink stick body (not including protruding key elements). Similarly, the ink stick body has a vertical center of gravity 164 that is substantially midway between the top surface 154 of the ink stick body and the bottom surface 152 of the ink stick body.

**[0053]** The ink stick includes guide means for guiding the ink stick along a feed channel 128A-D of the solid ink feed system. A first guide element 166 formed in the ink stick body forms one portion of the ink stick guide means. The first ink stick guide element 166 is laterally offset from the lateral center of gravity 163 of the ink stick body. In this exemplary embodiment, the first guide element 166 is adjacent one of the lateral sides of the ink stick body. In the illustrated embodiment, the first ink stick guide element 166 is formed in the ink stick body as a lower ink stick guide element 166 substantially below the vertical center of gravity 164. In this exemplary embodiment, the lower guide element 166 is adjacent one of the lateral sides of the ink stick body. In the embodiment illustrated in Figure 12, the lower ink stick guide element is formed in the bottom surface 152 of the ink stick body, and in particular is formed as a protrusion from the bottom surface of the ink stick body. This protruding guide element is formed at or near a first lateral edge 158A of the bottom surface. The protruding guide element 166 extends along the length of the ink stick body, from the leading (front) end surface to the trailing (rear) end surface. The guide element has a lateral dimension of approximately 0.12 inches (3.0 mm) and protrudes approximately 0.08 – 0.2 inches (2.0 – 5.0 mm) from the bottom surface of the ink stick body. The protruding guide element 166 tapers from its proximal base, where it joins the main ink stick body, to its distal tip. The distal tip may be somewhat rounded. The guide element encompasses no more than approximately 30% of the width of the bottom portion of the feed stick, and particularly is approximately 15% of the width of the bottom surface 152 of the ink stick.

**[0054]** Figure 13 shows a cross sectional view of a particular embodiment of the longitudinal feed channel 128 of the solid ink feed system. The feed channel includes a feed channel guide rail 140 positioned in a lower portion of the feed channel. This feed channel guide rail 140 provides feed system guide means for guiding the ink stick 130 in the feed channel. The first ink stick guide element 166 interacts with a first portion of the feed channel, and in particular the feed channel guide rail 140, to guide the ink stick along the feed channel 128. The feed channel

guide rail 140 of the solid ink feed system and the first guide element 166 formed in the ink stick body have compatible or complementary shapes. The complementary shapes allow the lower guide element 166 of the ink stick body to slidingly engage the feed channel guide rail 140 of the ink stick feed channel 128. The contact between the lower guide element 166 and the feed channel guide rail 140 becomes the primary load-bearing contact between the ink stick and the feed channel.

**[0055]** The surface of the feed channel guide rail that contacts the lower guide element of the ink stick is formed of a non-marking material to which the material forming the ink sticks does not adhere or build up, or that readily sheds the ink stick material. This non-marking surface material is non-deformable and very smooth, so that it does not abrade the ink sticks, and has a low surface energy. As seen in the enlarged view of Figure 13B, in one embodiment, the portion of the feed channel guide rail 140 that comes into contact with the lower guide element 166 of the ink stick is covered with a non-marking coating 141. This non-marking coating reduces friction between the feed channel guide rail 140 and the lower ink stick guide element 166 so that the ink stick moves freely along the feed channel. This non-marking coating 141 is on the portion of the feed channel that forms the principal load-bearing contact with the ink stick. As noted above, this non-marking coating may be a polyetrafluoroethylene (PTFE) film applied as a tape to the feed channel guide rail.

**[0056]** The width of the feed channel guide rail 140 is substantially less than the width of the feed channel. A majority of the bottom of the feed channel is recessed or open, so that it does not contact the bottom surface 152 of the ink stick 130. The recessed or open bottom of the feed channel allows flakes or chips of the ink stick material to fall away, so that such flakes or chips do not interfere with the sliding movement of the ink stick along the feed channel. The guide rail encompasses less than 30%, and particularly 5% - 25%, and more particularly approximately 15% of the width of the feed channel.

**[0057]** The feed channel guide rail 140 is suspended from a first side wall 142 of the feed channel. A second side wall 144 is on the opposite side of the feed channel. The side walls 142, 144 need not be solid, as the side surfaces 156 of the ink stick do not slide along them. Partial side walls may be advantageous in reducing the weight of the ink feed system. Certain environments can suggest having the guide rail 140 supported by a structure rising from the bottom of the ink feed system, rather than suspended from the side wall.

**[0058]** The weight of the ink stick body provides a vertical force to the interaction between the ink stick body guide element 166 and the feed channel guide rail 140 of the ink stick feed system. With the guide element of the ink stick body significantly offset laterally from the lateral center of gravity of the ink stick body, the ink stick body in the feed channel tends to rotate about a pivot point formed by the engagement of the ink stick guide element with the feed channel guide rail. The feed channel guide rail provides sufficient lateral resistance to movement of the ink stick guide element 166 that the ink stick guide element 166 remains in the feed channel guide rail 140. The contoured shape of the feed channel guide rail provides this lateral resistance.

**[0059]** The ink stick body additionally includes a second ink stick guide element 168 that guides another portion of the ink stick body along another portion of the feed channel, such as a second, upper guide rail 148 in the feed channel. The upper ink stick guide element 168 forms an additional portion of the ink stick guide means. The second ink stick guide element 168 is formed on the opposite side of the lateral center of gravity 163 from the first ink stick guide element 166. In the illustrated embodiment, the second ink stick guide element is formed in the ink stick body above the vertical center of gravity 164 of the ink stick body. Further, the second ink stick upper guide element is formed of a portion of the lateral side surface 156 of the ink stick body. For example, the second ink stick guide element is that upper portion of the lateral side surface adjacent the intersection of the lateral side

surface 156 with the top surface 154 of the ink stick body. If at least the upper portions of the side surfaces 156 of the ink stick body are substantially vertical, the intersection of the lateral side surface with the top surface forms substantially a right angle. Alternatively, the lateral side surfaces (or at least at the upper portions thereof) may be angled or segmented to provide a protruding portion of the lateral side wall as the upper guide element. In either case, the lateral side surface containing the upper guide element also intersects the bottom surface 152 of the ink stick body on the lateral edge 158B of the bottom surface opposite the lateral edge nearest the lower guide element 166. Thus, the upper edge forming the upper guide element 168 corresponds to the bottom surface lateral edge 158B opposite the lateral edge 158A nearest the lower guide element 166.

**[0060]** As seen in Figure 13, the upper ink stick guide element 168 slidingly engages the upper feed channel guide rail 148 of the solid ink feed system. The upper feed channel guide rail can be formed as part of the key plate 126 that covers the feed channel, or as a part of the feed channel body. The upper feed channel guide rail 148 is positioned so that the upper ink stick guide element 168 exerts a slight lateral force on the upper guide rail. This lateral force tends to minimize the engagement force between the upper ink stick guide element and the upper feed channel guide rail. Those skilled in the art will recognize that the upper ink stick guide element can take on other forms than these specific shapes illustrated.

**[0061]** The surface of the upper feed channel guide rail 148 is also formed with a non-marking material. In the embodiment shown, a non-marking coating 161 (Figure 13A) covers that portion of the surface of the upper feed channel guide rail that comes into contact with the upper ink stick guide element 168 of the ink stick.

**[0062]** The longitudinal ink stick guide element 166 in the bottom surface of the ink stick body and the feed channel guide rail 140 cooperate to maintain the orientation of the ink stick as the ink stick progresses along the length of the feed channel from the feed end to the melt end. The ink stick guide element 166 and the

feed channel guide rail 140 forming the guide means keep the ink stick aligned with the feed channel. The ink stick body does not become skewed with respect to the feed channel. With the ink stick properly aligned with the feed channel, the ink stick meets the melt plate 32 normal to the melt plate surface. Proper alignment between the ink stick and the melt plate enhances even melting of the ink stick. Even melting reduces the formation of unmelted corner slivers at the trailing end of each ink stick. Such unmelted corner slivers may slip through the gap 33 between the melt plate and the end of the feed channel. Such slivers may interfere with the proper functioning of certain portions of the printer.

**[0063]** The ink stick is guided along the feed channel 128 with only two lines of contact (or points of contact if discontinuous ink stick guide elements are used) between the ink stick body and the feed channel – the lower ink stick guide element 166 contacting the non-marking coating 141 on the lower feed channel guide rail 140, and the upper ink stick guide element 168 contacting the non-marking coating 161 on upper feed channel guide rail 148. This arrangement provides greater accuracy in guiding the ink stick along the feed channel, so that the ink stick retains its orientation in the feed channel as the ink stick progresses toward the melt plate 32.

**[0064]** In certain implementations of the ink stick, the lower guide element 166 is formed slightly spaced from the lateral edge 158A of the ink stick body. This spacing reduces the stress on the guide element that might tend to cause portions of the guide element or adjacent portions of the ink stick body to break off.

**[0065]** Key element shapes in the lateral side surfaces 156 of the ink stick body may tend to affect the orientation of the ink stick body as the ink stick moves along the feed channel. The interaction of the guide element 166 and the guide rail 140 counteracts that tendency, and maintains the correct orientation of the ink stick in the feed channel. The cooperative action of the ink stick guide element 166 and the feed channel guide rail 140 also reduce the "steering" effect the push block 34 acting on the trailing end surface of the ink stick in the feed channel 128. Thus, laterally

offset pressure by the ink block is of lesser concern, and maintaining a perfect lat ral balance of the force exerted by the push block on the ink stick is less critical than with certain other designs.

**[0066]** Figures 14 through 22 show ink sticks having alternative shapes for the ink stick guide element. As seen in Figure 14, the bottom surface of the ink stick body can be neither horizontal nor flat.

**[0067]** Figure 14 illustrates an ink stick 430 in which the bottom surface of the ink stick body is curved, rather than flat. A first lower ink stick guide element 466 is laterally offset to one side of the lateral center of gravity of the ink stick. The first lower ink stick guide element 466 slidingly engages a first feed channel guide rail 440 in the lower portion of the feed channel 428. As seen more clearly in the enlarged view of Figure 14C, a non-marking coating 441 covers the portion of the first feed channel guide rail 440 that comes into contact with the first lower ink stick guide element 466 to reduce friction between the first feed channel guide rail and the first lower ink stick guide element. With the particular shape to the bottom surface 452 shown in Figure 14, a second guide element 467 can be formed in the bottom surface of the ink stick body, on the side opposite from the first lower guide element 466. This second lower guide element can be in lieu of, or in addition to, the upper guide element 168 formed in the upper portion of the ink stick body. An ink stick feed channel for receiving an ink stick with such second lower guide element 467 has a second guide rail 448 in the lower portion of the feed channel for slidingly engaging the second lower guide element. This second lower guide rail 448 is substantially similar to the first lower guide rail 440. Referring to the enlarged view of Figure 14B, a non-marking coating 461 covers the portion of the second feed channel guide rail 448 that comes into contact with the second lower ink stick guide element 467 to reduce friction between the second feed channel guide rail and the second lower ink stick guide element. Although the illustration of Figure 14 includes both a second lower ink stick guide element 467 interacting with a second lower feed channel guide

rail 448 and an upper ink stick guide element 168 interacting with an upper feed channel guide rail 148, in most uses only one of those interactions is needed to guide the ink stick along the feed channel. The ink stick of Figure 14 need not use the second lower guide element 467, using only the upper guide element 168 to balance the interaction between the lower guide element 466 and the feed channel guide rail 440. In such an implementation, the only contact between the lower portion of the ink stick and the feed channel is the contact between the lower guide element 466 and the single feed channel guide rail 440 in the feed channel. In an alternative, the two lower ink stick guide elements 466, 467 each interact with the lower feed channel guide rails 440, 448, and the upper guide rail 148 is eliminated.

**[0068]** Figure 15 shows an ink stick embodiment 530 in which the laterally offset lower ink stick guide element 566 is recessed into the bottom surface 552 of the ink stick body. The feed channel guide rail 540 in the feed channel for such an ink stick is raised, with a shape complementary to the shape of the recessed ink stick guide element 466, to slidingly engage the recessed ink stick guide element. A non-marking coating 541 covers those portions of the feed channel guide rail 540 that contact the ink stick guide element 566. A second feed channel guide rail 148 engages a different portion of the ink stick body to balance the ink stick in the feed channel. A non-marking coating 161 covers the interior surface second feed channel guide rail 148.

**[0069]** Figures 16 and 17 show embodiments of the ink stick 630, 730 (respectively) in which the lower ink stick guide element 666, 766 is formed on a lateral side surface of the ink stick body. The ink stick guide element is formed in the ink stick body below the vertical center of gravity. The side surface of the feed channel of the ink stick feed system for such an ink stick is correspondingly formed with a complementary feed channel guide rail 640, 740 to engage such an ink stick guide element formed on the side surface of the ink stick body. The ink stick embodiment illustrated in Figure 16 includes a protruding ink stick guide element 666

from the side surface 656 of the ink stick body. A non-marking coating 641 covers the feed channel guide rail. The ink stick body tends to pivot about the line at which the ink stick guide element 666 and the feed channel guide rail 640 interact. Therefore, the slope of the feed channel guide rail 640 provides sufficient vertical resistance to the ink stick guide element to hold the ink stick in place. A second feed channel guide rail 648 in this embodiment not only helps to guide the ink stick as it moves along the feed channel, but also helps to hold the ink stick guide element 666 in the first feed channel guide rail 640. To do that, the second feed channel guide rail provides resistance in both the vertical and horizontal dimensions to movement of the second side of the ink stick body. The illustrated second feed channel guide rail 648 includes an angled element that interacts with the lower edge of the ink stick body. A non-marking coating 661 covers that portion of the second feed channel guide rail 648 that comes into contact with the ink stick. However, other configurations can also be used for the second feed channel guide rail 648. For example, the second feed channel guide rail can have separate elements, one of which is substantially aligned with the bottom surface of the ink stick, and another of which is substantially aligned with the second side surface of the ink stick body. Some feed channel and ink stick configurations may benefit from an additional vertical support for the ink stick, in the form of an additional portion of feed channel frame supporting a portion of the bottom surface of the ink stick body.

**[0070]** Figure 17 illustrates an embodiment of the ink stick 730 in which the lower ink stick guide element 766 is recessed into the side surface 756 of the ink stick body. The side of the feed channel includes a correspondingly shaped feed channel guide rail 740. A non-marking coating 741a, 741b covers those portions of the feed channel guide rail 740 that contact the lower end stick guide element 766 or other surfaces of the ink stick. In this embodiment also, a second feed channel guide rail 748 provides resistance in both the vertical and horizontal dimensions to movement of the second side of the ink stick body. The illustrated second feed channel guide rail includes an angled element that interacts with the lower edge of

the ink stick body. However, other configurations can also be used. The second feed channel guide rail 748 has a non-marking coating 761.

**[0071]** Figures 18 and 19 illustrate an embodiment of the ink stick 830 in which the surfaces of the ink stick body are curved, and a feed channel 828 for receiving such an ink stick. A first ink stick guide element 866 is formed in portion of the outer surface of the ink stick body, laterally offset from the lateral center of gravity of the ink stick body. The illustrated embodiment does not include edges at which flat surfaces meet. The curved bottom 852 of the ink stick body transitions into the curved sides 856, and the sides transition into the top 854. The ink stick body includes sufficient linear length to provide the first ink stick guide element 866 sufficient length between the ends 860 of the ink stick body to properly guide the ink stick along the feed channel guide rail 840. The feed channel 828 has a second feed channel guide rail 848 positioned to slidingly engage a second ink stick guide element 868. The second ink stick guide element 868 is that portion of the exterior of the ink stick body, such as a section of the side of the ink stick body, that contacts the second feed channel guide rail 868 in response to the tendency of the ink stick body to rotate about the line of interaction between the first ink stick guide element 866 and the first feed channel guide rail 840. A non-marking coating 861 forms the surface of the second feed channel guide rail 848 so that the portion of the exterior of the ink stick body that contacts the second feed channel guide rail actually contacts the non-marking coating. The ink stick can also incorporate a combination of flat surfaces and curved surfaces, so that a wide variety of ink stick shapes are compatible with the present invention.

**[0072]** Figure 20 shows an embodiment of the ink stick 930 in which the end surfaces 960 of the ink stick body are substantially flat, but not perpendicular to the lateral side surfaces 956. Thus, the bottom and top surfaces 952, 954 of the ink stick are not rectangular. The ink stick is illustrated as it is inserted through a correspondingly shaped key plate opening 924 in a printer key plate 926.

**[0073]** Figure 21 shows an embodiment of the ink stick 1030 in which the ink stick has a substantially cylindrical shape. This embodiment illustrates that the ends 1060 of the ink stick body and the sides 1056 do not need to meet at a corner of the ink stick body. The first ink stick guide element 1066, laterally offset from the lateral center of gravity 1062 of the primary portion of the ink stick body, extends linearly along a segment of the bottom 1052 of the ink stick body sufficient to permit the ink stick guide element 1066 to properly guide the ink stick along a feed channel guide rail in the feed channel (not shown). A portion of the outer surface of the side 1056 on the opposite side of the lateral center of gravity forms a second ink stick guide element 1068. The second ink stick guide element slidingly engages a second feed channel guide rail (not shown) in the ink feed channel of the printer.

**[0074]** Figure 22 shows yet another embodiment of the ink stick 1130, and corresponding feed channel 1128, to illustrate some of the numerous configurations possible. The ink stick 1130 of Figure 22 has a first ink stick guide element 1166 formed as a protrusion from the upper portion of a lateral side surface 1156 of the ink stick body. The protruding ink stick guide element 1166 rests on and slidingly engages a first feed channel guide rail 1140 that extends from the side wall 1142 of the feed channel. The first feed channel guide rail has a non-marking surface 1141. In the particular embodiment illustrated, the side of the ink stick body has an indentation just below the ink stick guide element 1166, to accommodate the end of the feed channel guide rail 1140. However, such an indentation is not necessary in all instances. The ink stick body tends to rotate about the line of contact or interaction between the ink stick guide element 1166 and the first ink channel guide rail 1140, so the feed channel includes a second feed channel guide rail 1148, which interacts with a second ink stick guide element 1168. The second ink stick guide element 1168 has a non-marking surface 1161, and slidingly engages the second feed channel guide rail 1148. The second ink stick guide element 1168 is shown at the bottom of the ink stick body. An upper ink stick guide element 168 engaging an upper feed channel guide rail 148 can be used in addition to the second ink stick

guide element 1168, or in some cases, in lieu of the second ink stick guide element 1168. The upper feed channel guide rail 148 has a non-marking surface 161.

**[0075]** Those skilled in the art will recognize that, with the protruding type of guide element such as shown in several of the illustrated embodiments, the protrusion need not necessarily extend along the entire length of the ink stick body from the leading end surface to the trailing end surface. The protruding guide element may be formed in one or more segments, each of which extends along only a portion of the length of the ink stick body. However, a guide element formed along the entire length of the ink stick body, or at least segments formed at or near the leading (front) end surface, and at or near the trailing (rear) end surface of the ink stick body provide improved leverage for maintaining the proper orientation of the ink stick in the feed channel of the solid ink feed system.

**[0076]** The non-marking surface for the feed channel guide rails of each of the embodiments described above may be provided with a coating other than the film tape described above. In addition, materials other than PTFE may be used for the non-marking surface. For example, other polyethylene materials may be used. In addition, other types of TEFLON® materials, available from DuPont of Wilmington, Delaware, USA, its licensees and customers, also provide an appropriate surface for the feed channel guide rail. For example, TEFLON® FEP (fluorinated ethylene propylene copolymer), TEFLON® amorphous fluoropolymers, or TEFLON® PFA (perfluoroalkoxy) may be appropriate. These materials typically have a water absorption factor of less than 0.01%, and a surface energy of less than 30 dynes/cm, and, for "stickier" ink or higher internal operating temperatures, a surface energy of less than 20 dynes/cm, and preferably a surface energy of less than 18 dynes/cm, or even 16 dynes/cm. In addition to the tape film format, the non-marking surface may be created by spraying or painting a liquid coating onto the surface of the guide rail.

**[0077]** In yet further alternatives the plastic or other material forming the feed channel guide rail may be impregnated with tetrafluoroethylene (TFE) fluorocarbon

polymers or fluorinated ethylene-propylene (FEP) resins or similar materials, so that the feed channel guide rail is formed of the non-marking material. One exemplary embodiment is shown in Figure 23. the illustrated embodiment is substantially similar to the embodiment shown in Figure 13. However, in lieu of the non-marking coating covering the lower feed channel guide rail, the lower feed channel guide rail 1240 of the feed channel 1228 is formed of a non-marking material. The non-marking lower feed channel guide rail is securely bonded or otherwise attached to the feed channel side wall 1242 of the feed channel. The upper feed channel guide rail 1248 can also be formed of the non-marking material. The non-marking upper feed channel guide rail is bonded or otherwise securely attached to the underside of a key plate 1226 that covers the feed channel 1228.

**[0078]** Persons skilled in the art, after reading the present description, will recognize that the other feed channel configurations described above can also be fabricated with the entire feed channel guide rails formed of non-marking material, such as plastic impregnated with a TEFLON® resin or similar material. Furthermore, after reading the present description, persons skilled in the art will also recognize that in certain applications the entire structure of the feed channel (side walls in addition to guide rails) may be formed of non-marking material.

**[0079]** A method of loading an ink stick into a solid ink feed system includes inserting the ink stick through the appropriately shaped keyed opening 24 or 124, and into the insertion end of the longitudinal feed channel, as seen in Figures 2, 3, and 10. The first, lower ink stick guide element 66, 166 is aligned with the feed channel guide rail 40, 140 in the ink stick feed channel (see Figures 4 and 13). The ink stick is placed in the channel with the ink stick guide element 66, 166 on the non-marking surface of the feed channel guide rail 40, 140 so that the contact between the ink stick guide element and the feed channel guide rail is substantially the only contact between the bottom surface of the ink stick and the feed system. With the embodiment shown in Figures 9 – 13, when the ink stick body is released into the

feed channel, the gravitational forces cause the upper ink stick guide element 168 of the ink stick body to engage the non-marking surface of the upper feed channel guide rail 148. In accordance with known techniques, the push block 34 in the feed channel pushes the ink stick along the length of the feed channel. For ink sticks similar to the embodiments illustrated in Figures 16 and 17, upon inserting the ink sticks into the insertion end of the feed channel, the user additionally longitudinally aligns the ink stick guide element 666, 766 with the corresponding feed channel guide rail 640, 740.

**[0080]** Those skilled in the art will recognize that corners and edges may have radii or other non-sharp configurations, depending on various factors, including manufacturing considerations. Numerous modifications can be made to the specific implementations described above. Those skilled in the art will recognize that the guide element in the bottom surface of the ink stick body, and the guide rail in the bottom of the feed channel may have numerous shapes other than the particular shapes illustrated. In addition, numerous other configurations of the feed channel, key plate, and other components of the ink feed system can be constructed within the scope of the invention. Therefore, the following claims are not to be limited to the specific embodiments illustrated and described above.

WE CLAIM: